Fisheries and the Environment (FATE)
Decadal Trends in Fisheries Productivity

An FY 2002 Fisheries Oceanography Implementation Plan

Executive Summary

Knowledge of decadal and basin-scale climate variability and its impacts on fisheries productivity is essential to effective fisheries management. Sudden shifts in climate regime, as seen recently in the North Pacific, have immediate and major impacts on fisheries productivity. Fisheries and the Environment (FATE) will provide the information necessary to effectively adapt management to mitigate the ecological, social and economic impacts of major shifts in the productivity of natural resources in the North Pacific, Bering Sea and Hawaiian Islands. We envision that through the implementation of common analyses and sampling strategies in distant regions we will be able to invoke comparative analyses to evaluate the response of marine fish to different types of climate forcing. Towards this goal, FATE will provide *leading indicators* of ecological and oceanographic change at the population and ecosystem level and local to ocean-basin scales. These will in turn be linked to *performance indicators* that will provide early warnings of major shifts in the productivity of key stocks as well as monitor current year trends in ocean conditions, fish production and ecosystem dynamics. While the initiative is based on an ecosystem approach, it will target a suite of commercially important species including groundfish, coastal pelagics, Pacific salmon and highly migratory fishes as well as protected species.

FATE is an iterative research program that continually evaluates an expanding array of ecological and oceanographic products used for fishery stock assessments. In the first year of operation, we propose to deliver and post on the FATE web site the first generation of leading ecological indicators. These time series of indicators shall be derived from existing measurement programs (NMFS stock assessment surveys, NOAA and NASA satellites, NBDC buoys, coastal C-MAN and tide stations, ships of opportunity and other programs). Importantly, this first generation of indicators will be of immediate benefit to stock analysts in evaluating the ocean-climate risk inherent in current year assessments, and harvest quotas. The quality and kinds of indicators will increase with each year as performance is evaluated and FATE research projects are completed. By the close of the second year, output from first generation of performance indicators, based on biophysical coupled models, will become available. Models will be validated by contrasting model predictions with the ecological indicators. This will allow us to critically evaluate model assumptions and parameterizations in a manner similar to most stock assessment models. The first generation of models will be designed to predict the likelihood of local and basin wide regime changes. The iterative process of prediction, comparison and evaluation will improve the capability of NMFS scientists to provide advice regarding ecosystem considerations in fisheries management. The indicators and models will most certainly identify specific measurement gaps and the need for a broader enhancement of existing observational programs. As program funding ramps up, some of these gaps will be filled by targeted spatial and temporal FATE measurement projects.

This implementation plan for FY 2002 outlines a $1.0M research program, which will be conducted through a continuing, core program in NMFS as well as through a partnership between NOAA and collaborating State, Federal and academic institutions.

Introduction

NMFS is responsible for the stewardship of the nation's living marine resources. The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), the Marine Mammal Protection Act and the Endangered Species Act all charge NMFS with the conservation and management of these resources. Moreover, the Sustainable Fisheries Act (§406) calls for NMFS to "expand the application of ecosystem principles in fishery conservation and management, including research." To meet this charge, NMFS convened the "Ecosystem Principles Advisory Panel" that completed its report[1] to Congress in 1999. That report suggests that NMFS must augment information obtained from commercial fisheries, observers and surveys of fish stocks. Research in fisheries oceanography provides an essential element of this ecosystem-based information. It will allow scientists and managers to understand multi-species interactions and the effects of ocean variability both on exploited populations as well as on non-exploited elements of the ecosystem such as forage fishes, birds, mammals, zooplankton and phytoplankton.

Ongoing regional research programs have laid the foundation for fisheries oceanography research and its application to ecosystem management. Using site intensive investigations, these studies have identified processes affecting stock productivity that are linked to ocean physics. Building on these results, FATE will respond to specific requirements in ecosystem-based fishery management by providing ecological and oceanographic indicators of annual to decadal changes in stock productivity, diagnostic models that will lead to new capabilities in forecasting resource productivity, and a new suite of measurements at local to ocean-basin scales.

FATE proposes a new model for research in fisheries oceanography that differs from past regional studies. Rather than regional process-oriented studies, FATE will approach the problem on the scale of the entire North Pacific basin. This broader approach is taken because climate processes affecting fisheries productivity operate on these scales. A core team of researchers, distributed among west coast NMFS research centers and entraining expertise from elsewhere in government and academia, will work together, combining a basin-scale approach with knowledge of the local expression of ecological change. With a management team directing the program, a combination of near-term products, long-term research, and carefully targeted monitoring will be developed. In the short term, FATE will provide leading ecological indicators, performance indicators, and annual reports on the state of the North Pacific ecosystems supporting fisheries and protected species. Long-term research will involve coupled regional-to-basin scale bio-physical models ultimately developing a predictive capacity. FATE will provide a new approach to meet the challenges of understanding the role of environmental variability needed for ecosystem-based management of living marine resources.

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[1] Ecosystem-Based Fishery Management. A Report to Congress by the Ecosystem Principles Advisory Panel. U.S. Dept. of Commerce, NOAA/NMFS. April, 1999. 54 p.

Background and Approach

Scales of Variability: Indicators of decadal shifts in productivity, a new focus for fishery oceanographic research, are of particular importance to fishery management. Studies of the population dynamics of marine species of the North Pacific demonstrate that decadal-scale variability in ocean climate can affect distribution, abundance, carrying capacity and, ultimately, fisheries productivity on a basin-scale. The sudden climate shifts that occurred in 1923, 1947 and 1976 in the North Pacific substantially altered marine ecosystems off Japan, Hawaii, Alaska, California, and Peru. Sardine stocks, salmon stocks, and west coast groundfish stocks off Japan, California and Peru exhibit synchronous shifts in productivity which appear to be the result of basin-wide changes in ocean climate. Salmon stocks in the Gulf of Alaska (GOA) and the California Current System (CCS) show abundance episodes that are out of phase – when salmon stocks do well in the GOA they do poorly in the CCS and vice versa. Similarly, climate episodes that favor Alaskan groundfish and salmon stocks are coincident with periods of low productivity for Oregon and Washington groundfish and salmon. The great recovery of the California sardine stock (from 20 MT -1.2 million MT) occurred during a 20-year warm period and was coincident with declines in northwest salmon and groundfish and bumper harvest of salmon in Alaska. Such decadal episodes in abundance are also evident in paleoceanographic records, where the scales of anchovy, sardine and hake are deposited in abundance periods averaging about 60 years. All of these lines of evidence indicate that these changes are driven by basin-wide changes in ocean and atmospheric circulation. Isaacs (1976) was the first to refer to these episodes in ocean climate as regimes and described them as "episodes locked into persistence" and pointed out that "fluctuations of populations must be related to these very large alternations". Regime shifts occur rapidly as the components of the climate system realign themselves, moving from one state to another, possibly in a period of months. The implications of regime shifts for fisheries management are significant because the classic fisheries management paradigm views recruitment as varying stochastically about a single long-term level. This paradigm is not consistent with the emerging view that there may be several, very different, mean recruitment levels, each one persisting for a decade or two followed by a rapid transition to another level. The ability to detect these impending regime shifts and predict their impacts on marine ecosystems and fisheries resources is critical to NMFS' stewardship mission. This topic has been taken up at the 2000 and 2001 NMFS National Stock Assessment Workshops (SAW). A key discussion item was the need for recognition of regime shifts in fisheries management. Participants agreed that the first step is to recognize when a shift has occurred so appropriate management measures can be taken. FATE will address exactly this problem early in the program.

We must also pay attention to variability at the interannual event scale. Events such as the El Nino-Southern Oscillation (ENSO) can also have significant impacts on fish distribution and survival, and affect reproduction and recruitment of West Coast stocks. The 1997-1998 ENSO event, one of the strongest recorded this century, has significantly changed the distribution of fish stocks off California, Oregon, Washington and Alaska, and the longer-term impacts of this event remain to be seen. Fisheries predictions are not possible in part because ENSO signals propagate to high-latitudes through the ocean as well as through the atmosphere. There is simply not sufficient information on the dynamics of North Pacific climate and how this is linked to equatorial El Nino events to adjust our fisheries predictions for such abrupt, far-reaching changes. Output from FATE will provide leading indicators of such extensive interannual changes for incorporation into annual stock assessments. Another important reason to focus on the ENSO signal is that the warm ocean regimes may be due in large part to increased frequency of El Nino-like conditions.

Relationship to other programs. This initiative complements the on-going research activities of several meso-scale process oriented research programs in the North Pacific and Bering Sea. Some of the formal research programs include the Southeast Bering Sea Carrying Capacity program, the Fisheries Oceanography Coordinated Investigations program (Central Gulf of Alaska), the U.S. GLOBEC Northeast Pacific research program (Northern Gulf of Alaska and the California Current), the Ocean Carrying Capacity study (Gulf of Alaska), the PICES Climate Change and Carrying Capacity program (North Pacific), and the CalCOFI program in the Southern California Bight. NOAA funded initiatives on Steller sea lions in FY2001 and 2002 have elements of sampling and oceanographic analysis involving modeling and other activities appropriate to FATE. Collaboration with these programs will leverage the resources to meet mutually important objectives. At the international level, SCOR recently formed Working Group 119, “Quantitative Ecosystem Indicators for Fisheries Management”, which is clearly related to FATE and will provide a source of intellectual collaboration. There are also a variety of smaller laboratory or individual investigator-based research studies in fisheries oceanography. These programs provide critical information required to formulate the governing equations and parameters used in bio-physical models. By virtue of its distribution among NMFS research centers, FATE will bridge the scale of these programs, and serve to leverage existing programs to jointly meet FATE’s objectives. In out-years, FATE will supply ocean measurements for use in model verification and to initiate a long-term sampling program that will allow NMFS scientists to respond to the onset of climate shifts.

The fisheries oceanography programs identified above in concert with Universities and Naval research institutes have assisted in the development of physical models for the California Current, Gulf of Alaska and Bering Sea. Efforts to couple biological models to these physical models are underway. The major barrier now inhibiting the use of coupled bio-physical models in developing fisheries advice is the lack of observations on the time and space scale required for model verification and prediction of fishery production. FATE and its research partners will provide much of the information needed to produce operational biophysical models that are properly initialized and verified by data from a strong observational program.

In summary, we view FATE serving as a focus to organize these research efforts towards issues of ecosystem-based fishery management, leveraging scientific results more far-reaching than the resources allocated would suggest. Although it will begin in the North Pacific, the approach taken will serve as a model to develop similar programs elsewhere.

Proposed Observation System: Monitoring the impact of shifts in ocean conditions requires a broad scale observational plan that fosters comparisons among distant regions. The approach of FATE shall be to use a system of widely distributed biological indicators of marine populations that can be viewed in the context of basin-wide changes in atmospheric and ocean circulation. This broad scale observation system composed of both biological and physical indicators is a departure from past fishery oceanography initiatives that have focused on regional or smaller scales. While these studies continue to provide a wealth of biological and physical detail they lack the connection to broad scale basin-wide forcing that is a common property of the dynamics of the major stocks of the west coasts of North America and Alaska, and the central concept of FATE. There are several advantages to a broad scale observation system. The most important is that the observational system takes advantage of the inter-regional coherence in the dynamics of stocks that is the signature of a regime shift. The changes in stock productivity are not all of the same sign; those of some West Coast rockfishes are negatively correlated with sardines, as are the correlations between Pacific Northwest and Alaskan salmon. The chief benefit of a wide array of biological properties is that collectively such biological changes serve as an early warning of a major basin-wide change in ocean climate regime affecting all ecosystems and many stocks as well as providing higher degrees of freedom for analysis. On the other hand, changes in a few indicators may indicate a local ecosystem event that is independent of a shift in ocean climate. Other benefits of developing a coastwide network of biological indicators is that many stocks are benefited rather than a few; further, the scale of observation is appropriate for even the largest stocks, such as sardine, hake, and selected highly migratory species, which extend far beyond the boundaries of any regional study.

It is important to recognize that simply computing the biological indicators is not sufficient to detect major shifts in ocean climate. It is the consistency of changes in the biological indicators with indicators of changes in atmospheric and ocean circulation that diagnose a regime shift. Similarly it is important to recognize that simply monitoring climate, without biological indicators, is not sufficient to anticipate regional ecosystem shifts. For example, the intensification and shift in the Aleutian Low Pressure System from 1977 to 1988 appears to have resulted in ecosystem shifts spanning the Pacific in both the subtropical and subarctic domain. However, a shift to a period characterized by weaker Aleutian Low Pressure System from 1989 - 1996 resulted in ecosystem changes apparent only in the subtropical but not subarctic gyres.

<u>Ecological indicators</u>: The linkage between climate and biological systems can be established through ecological observations, which produce time series of physical indicators. Similar in concept to leading economic indicators, leading ecological indicators are indices of ecosystem properties and processes that will reflect the condition of the ecosystem and the potential for fish population growth without requiring detailed information on the status of every component in the system. Currently, no comprehensive set of ecological indicators exists for any marine ecosystem. However, rich data sources exist from which such indicators can be extracted. These include NMFS fishery-independent surveys, commercial fishery catch data, and sampling of landings at dockside and various oceanographic data streams, oceanographic buoys and model output from ocean circulation models. In this initiative we will develop and evaluate a set of ecological indicators that index key ecological and physical processes in the North Pacific, and relate them to selected marine resources. The temporal resolution fields of oceanographic parameters will be obtained using measurements from existing and planned oceanographic measurements and assimilated into numerical models. In the beginning of this initiative no new field measurement programs will be implemented. Biological indicators will be derived from data or specimens and other materials routinely collected and archived by NMFS and other west coast resource agencies and the historical context of the indicators will be established through retrospective analysis of these data and materials.

A central theme of this initiative, and a feature that distinguishes it from all other fishery oceanography programs is that FATE will deliver useful leading ecological indicators of change from the onset of the program. In the beginning the initiative must depend on existing data streams and surveys to develop the initial indicators.   A second generation of indicators dependent upon on new surveys and modeling need to be developed once the basic indicator system is in place. Enhancements to this initiative in FY03 ($1.0M within BSF/Stock Assessment Improvement Plan) will allow us to begin the development of a second generation of indicators based on new surveys and on the output of diagnostic physical/biological ecosystem models developed through academic partnerships.

<u>Performance indicators</u>: As the FATE program develops and matures, certain biophysical indicators from the full suite of FATE indicators will be developed to describe how the ecosystem and its component elements, including fisheries, are performing. In an ecosystem-based management context, the goal will be to integrate products from FATE with information from stock assessments. FATE scientists will thus work jointly with stock assessment scientists and evaluate the performance indicators. This approach will maximize the utility and applicability of FATE research deliverables to NMFS management needs.

Research Modules: Physical and Biological Indicators

FATE will take a multidisciplinary approach to developing its leading ecological indicators. While we describe the general categories of physical and biological indicators and provide examples separately below, we will make work to merge and combine indicators as a prelude to development of FATE modeling efforts.

Physical indicators will use a combination of data sources and will include the following:

Remote sensing: Satellite-based measurements of sea surface temperature, sea surface height, surface chlorophyll, and winds, all with high temporal and spatial resolution, covering the North Pacific Ocean are currently being collected and will continue to be collected with subsequent generations of satellites. These data are extremely important to FATE because with minimal cost we can, in a timely fashion, characterize aspects of the physical and biological state of the entire North Pacific. Processing these data will enable us to describe how the magnitude and spatial patterns of selected parameters in the current year or season differs from previous periods. A focus of our work will be to compute and distribute indices derived from these satellite data which indicate regime shifts. While many scientists are using satellite data to describe ocean variation, most focus on specific sensors and/or regional processes. Our approach has a North Pacific scale; it emphasizes products that are likely to have ecosystem impacts and that are provided in a timely fashion to detect and describe a regime shift.

Derived oceanographic indices: Selected indicators in FATE will concentrate on measures of the state of the ocean. Several of these indices are proposed and will be derived from remote sensing (as noted above), as time series data of measured parameters (SST, subsurface temperature, sea level pressure, salinity, winds) and as derived indices (mixed layer depth, stratification, upwelling, transport, wind mixing, frontal location, etc.). Many of these indices exist in some form at the present time, but vast room for improvement exists. With the improved development of numerical ocean models, the opportunity to augment measurement with model produced values will allow us to "fill in the blanks" where data are missing. As an example, many environmental comparisons with ecological indicators rely on surface temperature, when subsurface temperature (or mixed layer depth) would be more biologically meaningful. If the latter are unavailable, however, the tendency is to use less appropriate, but more readily available, physical indices.

FATE will improve this situation. A good example is provided by the coastal upwelling index. Atmospheric pressure models integrate forcing across several processes in the coastal ocean. In many cases, however, long-standing relationships between the upwelling index and biological features (example -- coho salmon ocean survival) have broken down. FATE will develop a new index, the biologically effective upwelling index, which will evaluate the biological value of upwelling. The nature of the water being upwelled, the relationship to the mixed layer depth, the frequency of wind events stimulating upwelling, and the relationship to relaxation periods or storm frequency, for example, can all be used to relate to newly available chlorophyll measures from remote sensing of ocean color. Improved ecological indicators of this kind will serve to evaluate the state of the ocean for comparison with observed biological variability, improving our long term ability to predict changes in fisheries productivity.

Indicators of Atmospheric Forcing: An example of one of the basinwide synchronistic patterns of ocean physics is termed the Pacific Decadal Oscillation (PDO). During the positive phase of the PDO, there are colder temperatures in the mid-Pacific and warmer temperatures in a wide zone along the west coast of North America. The variability of other physical variables is related to the PDO. The increased or decreased ocean stratification reflected in the PDO is hypothesized to be the link between the physics and the biology. Increased stratification in the Gulf of Alaska promotes phytoplankton growth by overcoming light limitations. Off the U.S. West Coast, there is the opposite influence. Increased stratification due to decreased winds slows the supply of nutrients to the photic zone. Empirical studies show maximum salmon catches in Alaska versus the U.S. West Coast track variations in the PDO. Other species groups such as gadoids and bottom fish also appear to respond to the PDO.

FATE will use existing time series of atmospheric pressure to develop large-scale flow indices, regions of convergence, Ekman pumping, and other new indices that will help reveal the dynamics and mechanism of the relationship of these large-scale climate indices with biological features. We should also examine collaborations to develop non-traditional methods of analysis and thinking about these problems. In the first year, FATE will also collaborate with Russian scientists to evaluate their approaches to these problems, which differ from those traditionally taken here.

Real time monitoring: Examination of oceanographic data in the North Pacific basin reveals a lack of locations where long-term oceanographic measurements have made. A variety of oceanographic sampling schemes, such as the Global Ocean Observation System (GOOS) and the ARGO drifter program, are underway to address this shortcoming. For FY2002, FATE planned to deploy bio-physical moorings containing a suite of instruments that measure wind, humidity, rainfall, barometric pressure, air temperature and solar radiation on a surface platform and a dense array of subsurface instruments that will measure temperature, conductivity (salinity), currents, and chlorophyll. The two North Pacific sites were to have two moorings, with the upper ocean (above 250m) instrumentation focused on the surface moorings and currents and deeper temperature and salinity on the subsurface instrument.   Because funds for this part of FATE ($0.5M for OAR) were withdrawn, we will continue seeking the funds and will examine cooperative funding in FY 2003.

Biological indicators will play an important role in FATE's research and will serve as both leading indicators and performance indicators. While much biological data are available and existing scientific programs may develop indicators as FATE develops, the term funds allocated each year will provide a means to further develop this program and refine indices where further research is needed by NMFS and academic collaborators. These indicators include the following:

Analysis of fish distribution and migration: Shifts in spatial distributions and migration routes or rates of pelagic fishes ranging from sardines to bluefin tunas have been observed during regime shifts. Changes in distributions and migrations of marine organisms may occur in response to changes in ocean habitat and/or forage and hence may serve as excellent indicators of regional ecosystem change. For example, the recent expansion of the California sardine into coastal waters off Oregon and Washington may be an early indicator of ecosystem changes in that region. FATE will develop indices of migration and distribution to monitor trends for key species.

Analysis of community structure: Distinguishing shifts in ecosystem properties induced by humans from natural variability in the same properties is a challenging objective, particularly since the mechanisms causing variability in individual stocks remains uncertain. Trends in community structure based on species and diversity, biological characteristics within species, and food chain dynamics will be used to develop indicators that can be monitored on an annual basis. FATE's research in this area should point the way to developing targeted field collections to improve our understanding of the predator-prey interactions within selected systems.

Analysis of annual growth patterns: Fish growth and its interannual variability represent an integrated picture of environmental and trophic conditions that varies from species to species. Measurement of annual growth patterns in a retrospective sense will allow us to develop time series of growth for key species as they relate to environmental variability over decadal time scales. FATE will develop these growth parameters for many species along the west coast and Alaska, and if possible, for the same species in different parts of their range. Comparison of the growth patterns with environmental variability, much like the comparison of year class strength among diverse species, can lead to new insights about how fish respond to environmental variability on long time scales.

Analysis of trends in fishery production: The fisheries literature is replete with retrospective studies comparing oceanographic conditions to time series of fish production. Many of these studies provided the first tangible evidence of large-scale synchronous shifts in marine fish communities. FATE will support the development of a comprehensive database of fish production indices (e.g. catch, recruitment, biomass, and spawning biomass).   This database will form a valuable metric of large-scale ocean forcing on the production of synchronous extreme (strong or weak) year-classes and / or shifts in production in distant regions of the North Pacific.

Analysis of trends in secondary production: Regime shifts involve shifts in ecosystem structure; therefore such shifts should be manifest first in lower trophic level organisms. Monitoring of coastal zooplankton is an inexpensive and cost-effective activity that can provide early warning of ecosystem change (for lower trophic level organisms) resulting from regime shifts. Lower trophic level biomass data will also be extremely valuable as input into ecosystem models when we get to that point in our program, and the zooplankton data would contribute to our proposed annual assessment of the "State of the Ocean".

Data Management

Data management for this program will largely be handled at the individual investigator level through the research phase of development and validation of the ecological indicators. An important feature of the FATE program, however, is its dedication to assure that all of its research and particularly its ecological indicators are readily available to other researchers. For this reason, we are planning a unified data management system similar to the GLOBEC model. All indices developed under this program will be available through the WWW. While the individual indices and their calculations may be maintained on the web pages of individual researchers, FATE will have a dedicated web page with access to the indices and any ancillary data developed in this program. Descriptions of the indices and their derivations will also be on the web page, along with links to other environmental data appropriate for fisheries applications.

The central web site for FATE will be located at the Southwest Fisheries Science Center's Pacific Fisheries Environmental Laboratory. In addition to its research role, this laboratory has a long history of providing environmental data products tailored to fisheries research and management applications. PFEL derives a number of well-known environmental data and index products from the Navy's FNMOC data and routinely distributes these data to researchers at many state and federal laboratories, as well as to academic and international researchers. The coastal upwelling index, which reflects the strength of wind forcing on the ocean, has been used in many studies of the effects of ocean variability on the reproductive and recruitment success of fish and invertebrate species. New developments in web-based product delivery will be continued, such as the implementation of the Live Access Server for environmental data at PFEL. The overall goals are first to assure the widest possible dissemination and utility of the ecological indicators developed in FATE and second to seek improvement in the manner that environmental variability is utilized for applied aspects of fisheries such as stock assessment and management.

Program implementation and management

FATE will continue over the long term as a part of NMFS new initiatives in ecosystem-based fishery management. Thus, funds will be provided to the field as PPA permanent additions to base following the model of the F/PR ESA Salmon program. Central to the management of FATE is a basin-wide, coordinated, research network with staff fully committed to FATE objectives, for example, the annual production of leading ecological and performance indicators; conducting the science required to enhance this information; and to facilitating the use of FATE information in improving stock assessments. To assure that these responsibilities are met, a permanently allocated FATE-researcher will be located at each NMFS node of the FATE network; 4 FTEs are allocated in FY02 and an additional 2 FTEs are planned for FY03. The remaining funds (at the start up level) will be allocated on a term basis, to model development by academic researchers, data management, and program management. The dispensation of these funds shall be overseen by a program steering committee consisting of representatives from each participating NMFS node. These funds are viewed as mechanisms for bringing in new ideas from the academic community on modeling approaches, and synthesis into the FATE program. Thus permanent or long-term commitment of these funds is to be avoided. It is critical that the funds be used opportunistically to bring in the best minds to deal with synthesis and application of FATE results to practical problems in ecosystem-based fisheries management.

Assessment of progress will be gauged by a combination of collaboration and self-evaluation. In addition to the steering committee meetings, every two years FATE will convene a meeting to evaluate its products and progress and the degree to which the results are being applied to NMFS needs and fishery management problems. Research reviews and evaluation will allow improvement of the program by its peers and provide guidance to the steering committee. Collaboration with NMFS stock assessment scientists will be enhanced by presentations at NMFS' annual stock assessment workshops. The goal is to improve FATE's ability to work toward greater applicability of its products to the NMFS mission.

The Steering Committee shall consist of the principal investigators who developed FATE initiative, including:
George Boehlert, F/SWC, Pacific Grove
Ned Cyr, F/ST, Silver Spring
Ann Hollowed, F/AKC, Seattle
John Hunter, F/SWC, La Jolla
Bill Peterson, F/NWC, Newport
Jeffrey Polovina, F/SWC, Honolulu

The role of the Steering Committee will be to assure that FATE achieves its accomplishments as planned and evolves as a program to will meet the needs of NMFS. By receiving funds for FATE each Center is committing to this program. The steering committee shall assure accountability for project funds, make allocation decisions regarding term funding of projects, and hold the responsibility for generation annual status reports on the environment. The steering committee will have regular teleconferences, and a mandated annual meeting (funded by project management funds).

Clients

NMFS and state stock assessment analysts, fishery management councils and staff are the major FATE clients, for it is only through the incorporation of FATE products in fishery stock assessments, and harvest plans and guidelines, that FATE program goals can be met. Other clients exist for FATE products outside of the stock assessment and fisheries management arena, however.   Commercial and recreational fishers are deeply interested in environmental effects on the distribution and timing of seasonal movements of pelagic fishes, as well as being interested in the role of environment in the fate of fish populations. Knowing when where pelagic fishes occur is a key element of fishing itself, hence information on fish distribution can serve as a strong public outreach for the FATE program, as well as providing biological indicators of ocean change. Thus, FATE is committed to highlight indicators of distribution change in pelagic fishes or timing and extent of seasonal movements on its website. This will be done for stocks important to pelagic fishers along the west coast, where such time series information exists. Another group of clients for FATE products are NGO's and other components of the public interested in long-term effects of fishing on ecosystems. The FATE management team view indicators of ecosystem health as a longer-term goal of the program. Clearly the leading ecological indicators generated in the first and subsequent years of FATE can serve as essential building blocks for an ecosystem health appraisal system.

Products and Deliverables

FATE will develop products described above, which will include the following:

<u>Ecological Indicators</u>: FATE principal investigators have developed a list of leading and performance indicators. Many of these are ready for development with scientific effort and will not immediately require additional field programs or support to develop. Others will require additional support; it is anticipated that the development of the highest priority indicators will be one use of the opportunity funds.

<u>FATE Web page and data management system</u>: It is our intent to make the ecological indicators, and if appropriate, the physical data used to develop them, available on the WWW for extensive use by other researchers in government and academia. A web page will be developed in FY 2002 and it will evolve with time. These activities will be housed at the Pacific Fisheries Environmental Laboratory.

<u>“State of the ecosystem” reports</u>: The ecological indicators along with analysis of other physical and biological ecosystem components will be used by FATE researchers to develop both oral and written syntheses each year. Modeled on the “State of the California Current” report presented each year at the CalCOFI conference, these reports could be tailored for each Fishery Management Council and published as a single synthesis each year as well as abridged versions that can be included in the NMFS publication Our Living Oceans. Responsibilities for completion of these reports would be distributed among FATE researchers. There would also be collaboration with PICES in development of the planned “State of the North Pacific” report.

FY 2002 Budget

The FY2002 budget (000's) for FATE is outlined below.

Personnel

FTE Costs (4 oceanographers @$142k)	$568k
Program Management Funds	
Travel	$ 12k
Data Management, Web Page	$ 50k
Research: Opportunity Funds	$ 370k
FATE FY 2002 Total Budget	$1,000k